TIROS V VIEWS FINAL STAGES IN THE LIFE OF TYPHOON SARAH AUGUST 1962

CAPT. ROBERT W. FETT, AWS MEMBER

National Weather Satellite Center, Washington, D.C.

[Manuscript Received April 18, 1963; Revised May 28, 1963]

ABSTRACT

Four TIROS V mosaics showing typhoon Sarah on consecutive days during the period of its decline are described. The initial development of what later became typhoon Vera is also shown. It is found that marked changes in storm intensity are reflected in corresponding changes of appearance in the cloud patterns viewed from the satellite.

1. INTRODUCTION

The 3-week period from the middle of August through the first week of September 1962, was one of unusual activity for the western Pacific. No fewer than 6 typhoons developed, ran their devastating courses, and finally dissipated in mid-latitudes during this short span of time.[1]

The TIROS V meteorological satellite was in position to view many of these developments during various stages of growth from formation to final decay. This provided an unparalleled opportunity to obtain a visual record for extensive research into many of the still unresolved questions posed concerning the nature of the storms—particularly questions concerning origin and changes in structure or appearance at different stages of development. Many fine pictures were obtained on consecutive days over individual storms. The research in progress has raised many additional questions as pictures are carefully related to conventional information available and various theories and hypotheses are tested. Meanwhile the fascinating visual account obtained by TIROS V remains. Of all the pictures taken, one of the most interesting and immediately suggestive sequences depicts the demise of typhoon Sarah during the period August 20–23, 1962.

2. DESCRIPTION OF MOSAICS

Figure 1 shows a mosaic displaying typhoon Sarah at maturity during the first day of this period. The operational nephanalysis prepared at Point Mugu, Calif. (PMR) read-out station shortly after the pictures were taken is also shown. Through cross reference from the mosaic to the nephanalysis, locations of cloud features can conveniently be determined. Photographic distortions of the pictures and mosaic presentation are also rectified on the nephanalysis. The pictures begin in the Southern Hemisphere and extend northeastward past the Philippines, over Formosa, Korea, and Japan, to the southern tip of the Kamchatka Peninsula. The predominant cloud features in the southern portion of the mosaic consist mainly of clusters of cumulonimbus with anvil tops sheared toward the west-southwest by strong upper-level east-northeasterly winds. This observation is supported by numerous ship and land station reports of cumulonimbus cloudiness just prior to the TIROS observations. In addition, Manila's 200-mb. wind for 0000 GMT, August 20, 1962 was from 060° at 30 kt. and Saigon's wind for the same time and level was 060° at 32 kt. The characteristic "carrot shaped" appearance of the cumulonimbus clouds, in this and other TIROS pictures, under conditions of strong upper shear seems to make them extremely valuable indicators of mean flow through the layer containing the anvil top.

The cloud system of typhoon Sarah with maximum winds of 75 kt. is visible approaching the island of Kyushu, Japan. Sarah was moving toward the north-northeast at this time at approximately 10 kt. Farther north, typhoon Ruth with maximum winds of 85 kt. is just visible with center approximately 75 mi. southeast of Tokyo.

Typhoon Sarah at this stage appears compact and similar to many radar photographs of hurricanes showing the typical spiral band structure so frequently observed. Its similarity in size and general appearance to a radar photograph of hurricane Donna, 1960, is noteworthy (fig. 2). An outer convective band or pre-hurricane squall line appears in the northeastern quadrant of Sarah (and also Donna), apparently separated from the main cloud mass

[1]

Storm	Bulletins issued
Typhoon Ruth	Aug. 13–22, 1962
Typhoon Sarah	Aug. 15–22, 1962
Typhoon Thelma	Aug. 21–27, 1962
Typhoon Vera	Aug. 25–28, 1962
Typhoon Wanda	Aug. 27–Sept. 8, 1962
Typhoon Amy	Aug. 29–Sept. 8, 1962

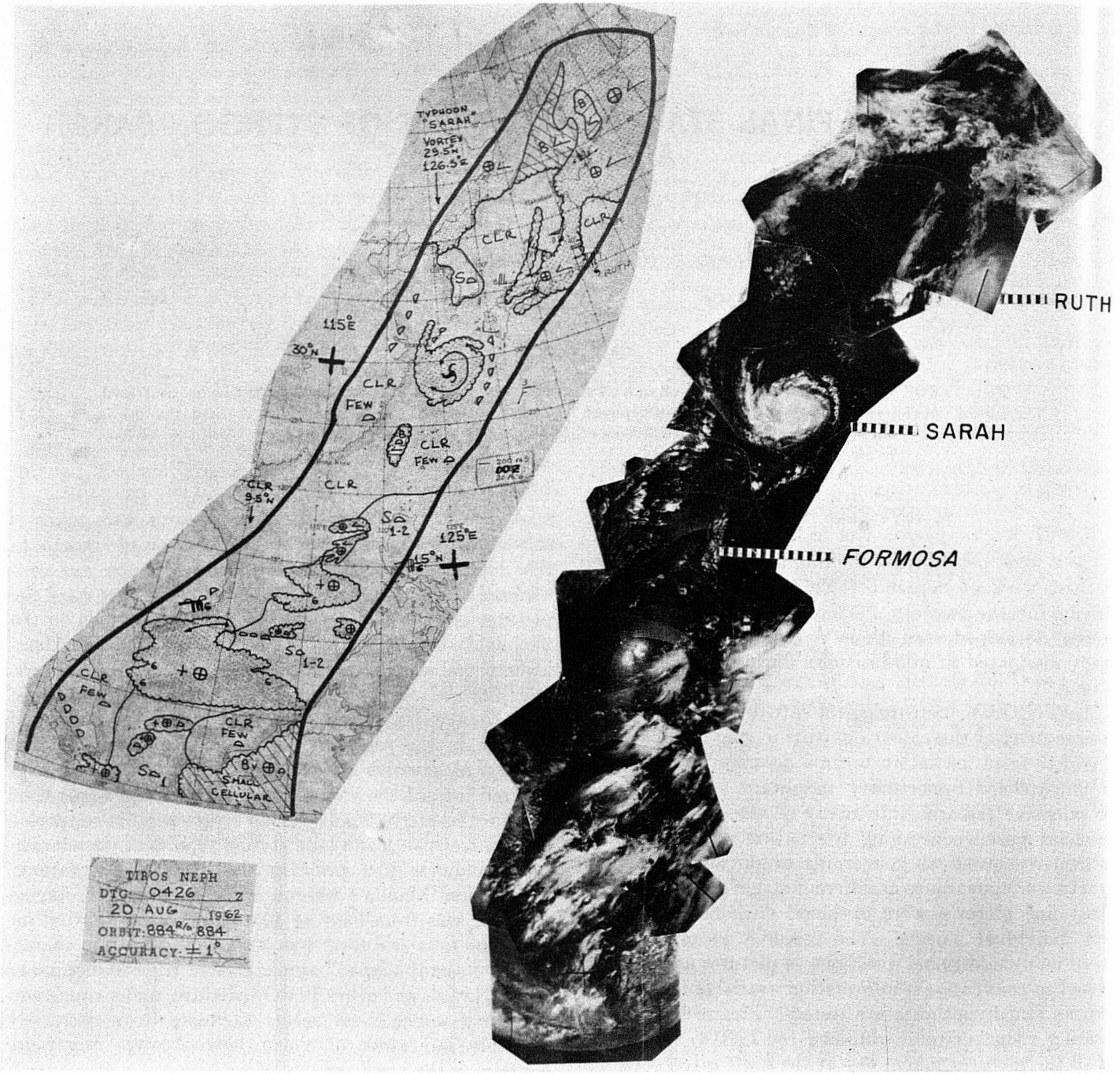

FIGURE 1.—A TIROS V mosaic and nephanalysis for orbital pass 884 on August 20, 1962, at 0426 GMT.

by 40 to 60 mi. [1]. Such bands have frequently been observed in satellite photographs, and were first documented in radar studies of hurricanes [2]. Convective clouds extending southwestward toward Formosa appear, also, to be typhoon derived.

The TIROS V view 24 hr. later (fig. 3) continues to be one of the most remarkable and revealing satellite views ever obtained. The outer edge of the major cloud mass of Sarah is shown in this figure, pressing upon the island of Kyushu, Japan, Terrain effects of the island appear to have contributed to the production of a relatively clear notch "cut" out from the northern boundary of the storm. The island of Kyushu lies directly under this notch. Some of the islands to the south of Kyushu extending toward Okinawa appear, also, to have made indentations along the eastern edge of the storm. It seems unlikely that the effect of the 15-kt. maximum surface winds over the mountainous terrain of Kyushu

would have been pronounced enough to have dissipated the cirrus cloudiness, normally found over the tropical cyclone in a solid sheet or "high cloud shield". Hence, one of two possibilities is suggested to explain the apparent absence of cloudiness over the notch area: (1) The cirrus cloudiness, forming the high cloud shield of the storm received major contributions from individual cumulonimbus clouds and spiral bands—these were dissipated over the terrain, hence the high cloud shield cannot be seen in these areas; (2) much of the cirrus cloudiness was unresolved by the TIROS cameras, and overcast cirrus cloudiness actually extended over the "clear" notch—the major bright outline of the typhoon, according to this argument, was formed by dense altostratus, cumulonimbus, and other water-droplet type clouds which extended low enough to be markedly influenced by terrain effects. Recent radar studies related to TIROS pictures [3] and abundant evidence suggesting the near transparency of much cirrus cloudiness to the TIROS wide-angle system suggest that the latter alternative is most probable. This line of reasoning could account for the similarity of many radar photographs of tropical cyclones, as shown in figure 2, to the TIROS wide-angle views of these storms.

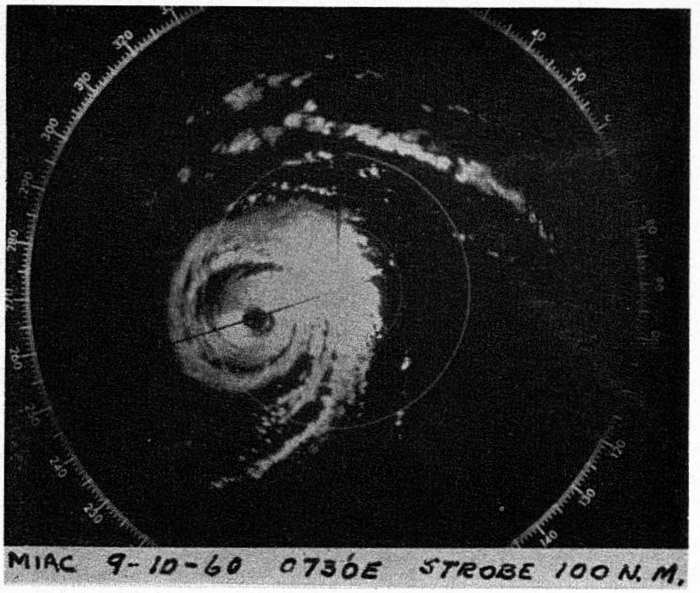

FIGURE 2.—A National Hurricane Center radar photograph of hurricane Donna, on September 10, 1960. The well marked circle denotes the 100-mi. range from scope center (at Miami). Note the squall line in the northern quadrants of the storm (north toward top of picture) nearly 200 mi. in advance of the eye of the storm.

The terrain, even at this stage, appears to have been a factor affecting storm intensity. Maximum wind speed at this time was reduced to 55 kt. as Sarah was downgraded from typhoon to tropical storm status. Typhoon Ruth is visible in this same picture sequence approximately 3° northeast of Tokyo with maximum winds of 80 kt. An extratropical vortex can be seen farther north with a frontal band extending southwestward.

The 200-mb. winds for 0000 GMT, August 21, 1962, reveal patterns of flow at upper levels around the typhoons, also suggested by the visible cirrus clouds in this mosaic. Several of these winds are plotted on the nephanalysis and arrows are drawn indicating some of the major streamlines. The anticyclone over each of the storms is clearly delineated by these winds. A squall line or outer convective band along the southern boundary of Sarah in this picture (fig. 3) apparently existed in a region of extreme vertical shear with low-level westerlies (as indicated by the U.S. Weather Bureau, Honolulu, surface analysis for 0000 GMT, August 21, 1962) and upper-level easterlies resulting in an elongation of the cumulonimbus cloud masses along their east-west axes. One notable effect, apparent at the 200-mb. level, is the development of winds of higher speed tangential to the typhoon cloudiness along the northern boundaries of each of these storms. Thus, on Kyushu, winds of 250° at 35 kt. were reported, and north of Ruth winds of 250° at 50 kt. and higher were evident. The development of these higher speed winds at the edge of storm cloudiness is being studied and has been noted in earlier reports [4, 5]. The general impression of east-northeasterly flow at upper levels over the Philippines and to the south is supported by Manila's 200-mb. wind of 070° at 30 kt., indicated on the mosaic.

On August 22, 1962 (24 hr. later) typhoon Sarah was again viewed by TIROS V (fig. 4). This mosaic shows Sarah over the Japanese Islands with maximum winds of 35 kt., a few hours before it was downgraded from tropical storm to tropical depression status. It appears visibly "shaken" by its encounter with the islands of Japan and quite obviously has weakened considerably from previous views. The central overcast cloud mass is smaller in size and does not appear as bright. The edge of the storm is much more poorly defined and no major bands can be seen spiralling into the major cloud area as in figure 1. No eye or clearly defined center of circulation can be determined. Typhoon Ruth has merged with the frontal system to the north but still appears vigorous with maximum winds of 70 kt. In fact, despite the poorer angle of view, the eye of Ruth is visible on this mosaic in the southwestern quadrant of the storm.

A "newcomer" has made its appearance on this mosaic southeast of Sarah. The cloud mass between 20° and 27° N. near 135° E. is an early stage in the development of typhoon Vera. Little evidence suggesting the presence of this disturbance could be derived at this time from conventional information available. The surface winds, undoubtedly, were still very light even near the storm center. Yet signs of activity and banded structure are very apparent in this TIROS view over three days before it became necessary to issue the first weather advisory concerning this storm (0600 GMT, Aug. 25, 1962).

The final mosaic (fig. 5) shows Sarah 6 hours after the last weather advisory was issued. Sarah no longer existed

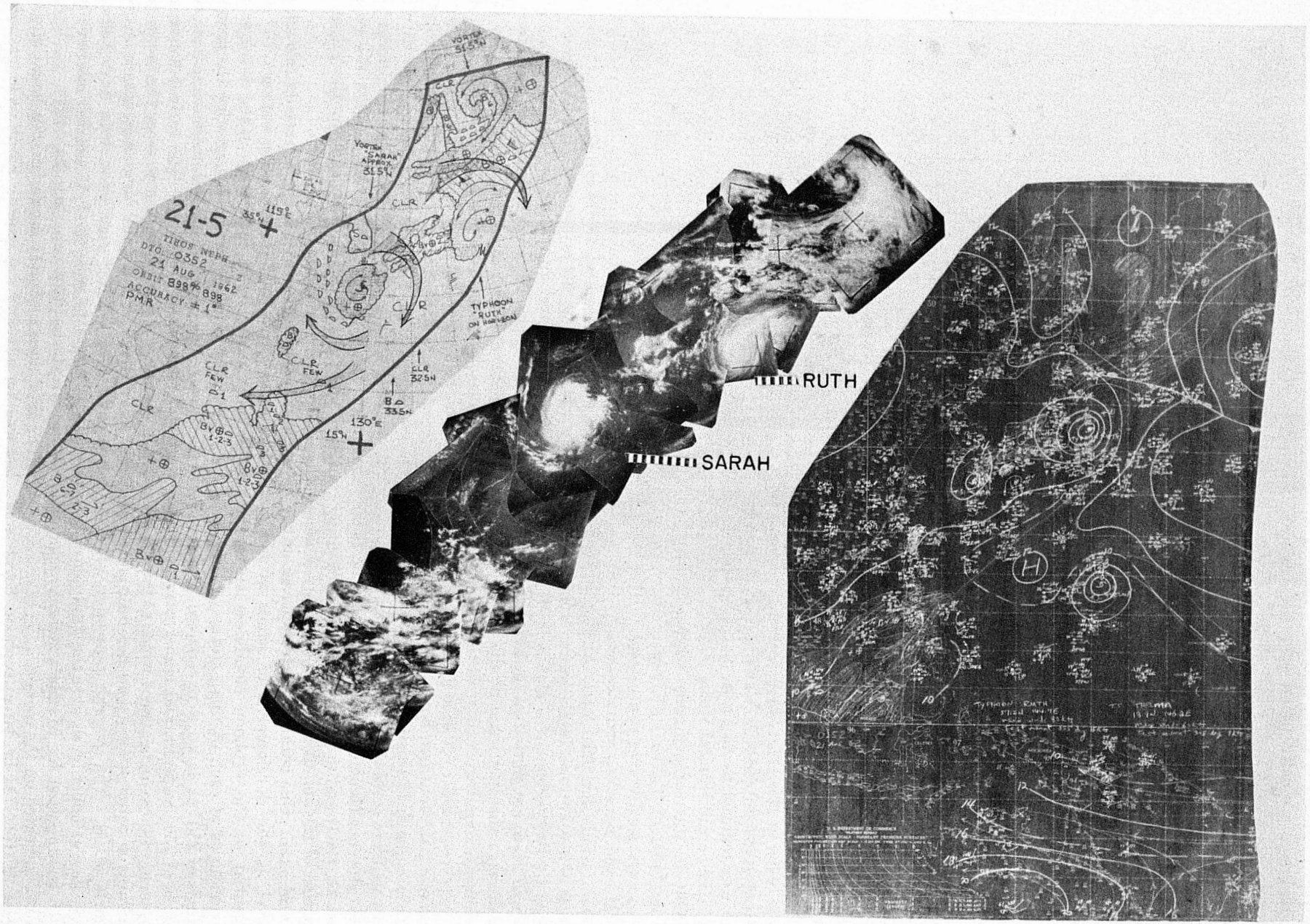

FIGURE 3.—A TIROS V mosaic and nephanalysis for pass 898 on August 21, 1962, at 0352 GMT. A section of the U.S. Weather Bureau (Honolulu) surface analysis for 0000 GMT, August 21, 1962, is also shown.

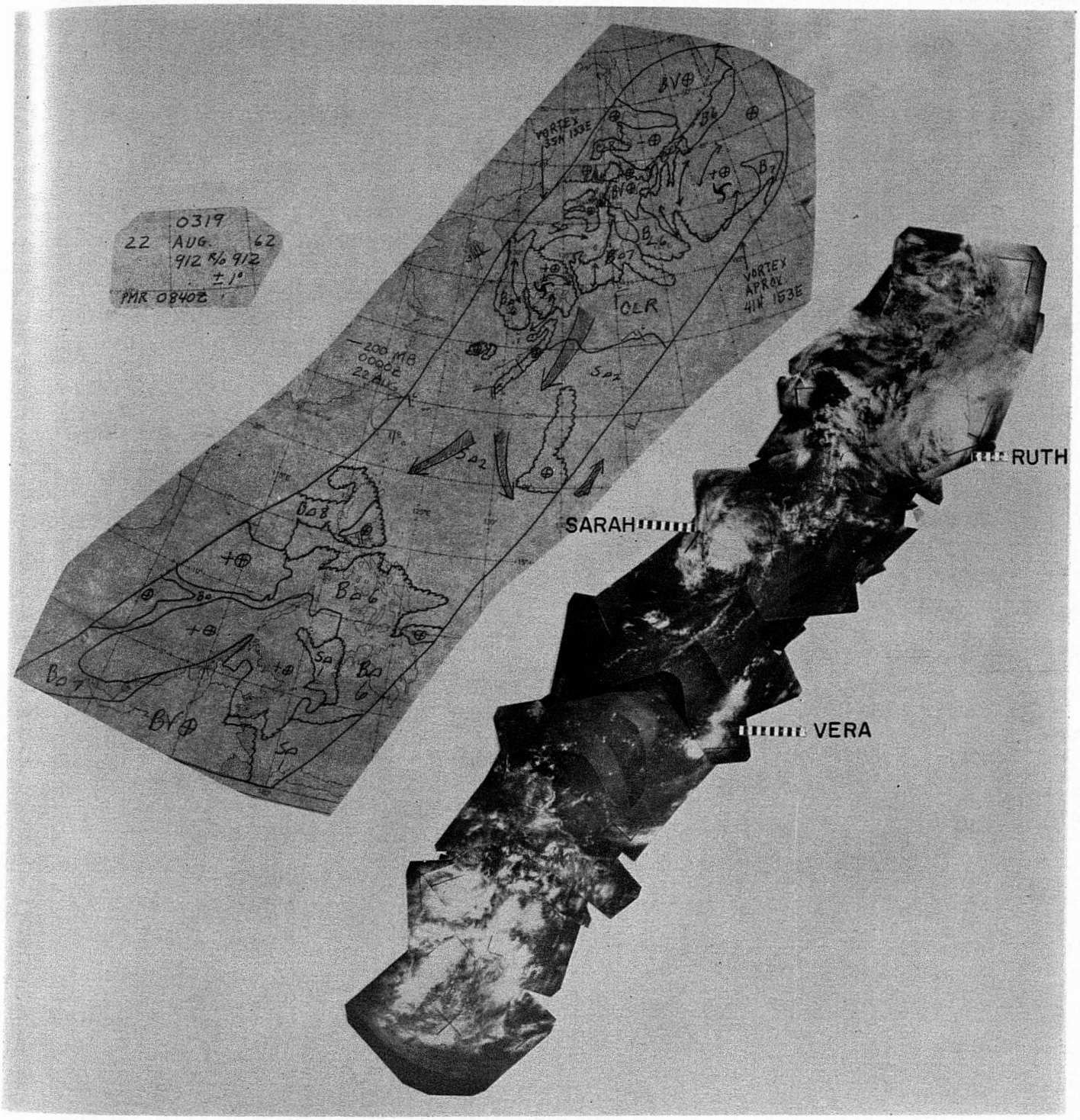

FIGURE 4.—A TIROS V mosaic and nephanalysis for pass 912 on August 22, 1962, at 0319 GMT.

as a separate well-defined cloud mass, but either had merged with other cloudiness or itself had spread out upon losing the essential features of circulation necessary to maintain itself in an independent fashion. Ruth is also visible to the north, now completely extratropical and dropped from the warning bulletins. The formative stage of typhoon Vera is again viewed near 20° N., 131° E. It has changed markedly in appearance from the previous view and appears to have intensified. It was previously elongated and appeared somewhat disconnected, in a series of weak looking segments. The view of the disturbance in figure 5, shows a much more compact organi-

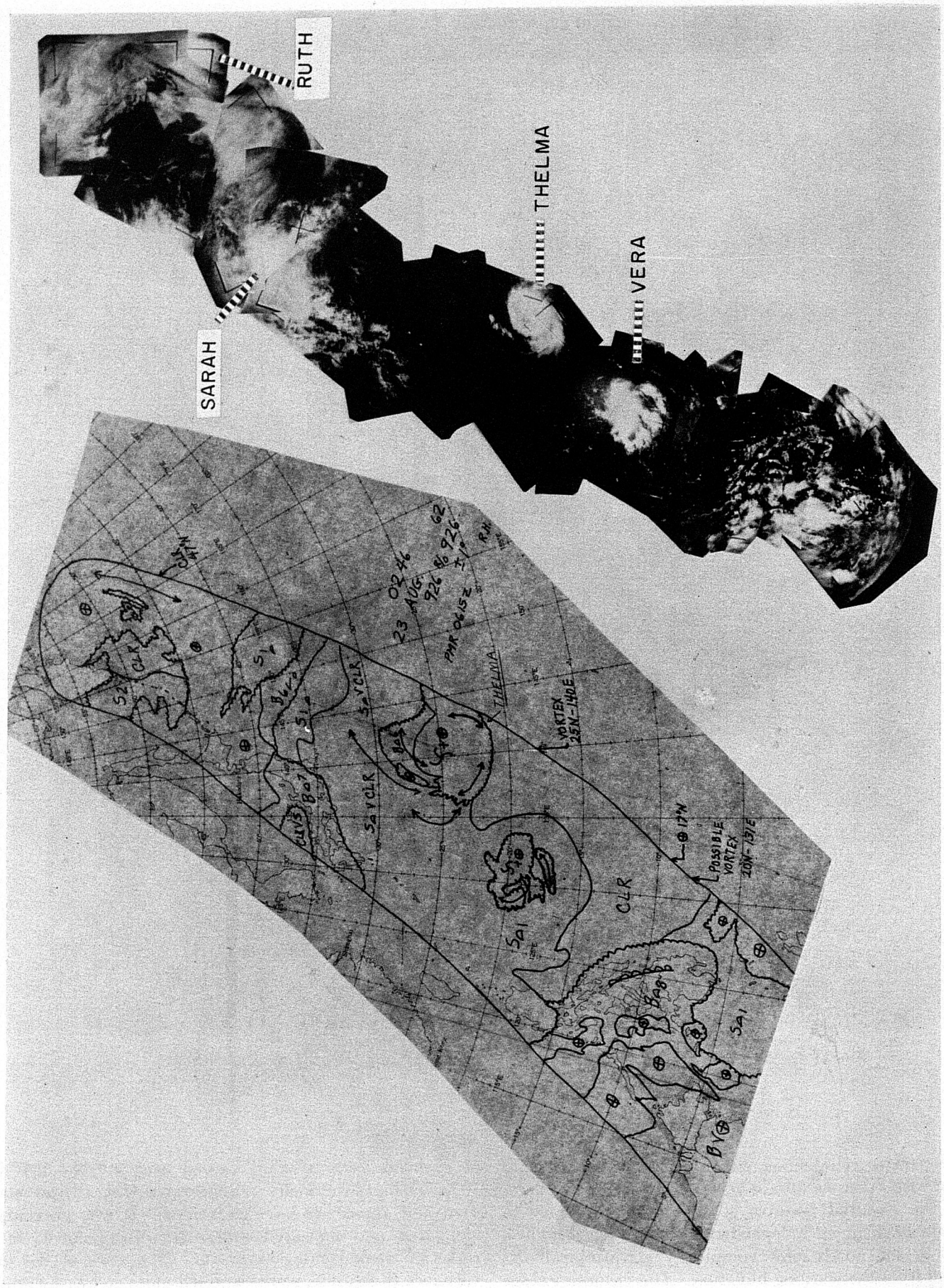

FIGURE 5.—A TIROS V mosaic and nephanalysis for pass 926 on August 23, 1962, at 0246 GMT.

zation with a clearly defined edge and a very bright central core. No definite center or eye can be seen, however, and it is unlikely that the surface winds had attained the speed required for designation as a tropical storm. Northeast of this disturbance typhoon Thelma appears with maximum winds of 75 kt. Thelma had moved into this area from the southeast after a trajectory of over 500 mi. as a storm of typhoon intensity. It was still intensifying at the time of this picture. The eye of the storm is visible on the mosaic near 25° N., 140° E. An outer convective band or pre-hurricane squall line is visible along the northwestern edge of the storm. Thelma appears quite similar at this stage of development to Sarah shown in figure 1. This mosaic is unique in the fact that four typhoons in various stages of development from incipiency to final decay are visible in a single pass.

3. SUMMARY

The TIROS V pictures showing the decline of typhoon Sarah and early stages of what later became typhoon Vera suggest that marked changes in intensity can be qualitatively determined in a comparison of successive satellite photographs over the storm. In sparse data areas where intensity cannot otherwise be determined this type of information could be of vital interest. An implication gained from the remarkable view of typhoon Sarah striking the island of Kyushu, Japan (fig. 3) is that the major outline of the storm, seen through the TIROS wide-angle system, is formed by water droplet clouds underlying the cirrus shield. This may explain the excellent correlation between satellite and radar photographs of hurricanes or typhoons. Cirrus clouds, by themselves, with no underlying cloudiness, appear to be much fainter and frequently invisible to the TIROS wide-angle system. The possibility of supplementing upper-air information through flow patterns suggested by visible cirrus streaks and anvil plumes appears very promising and should certainly receive further attention. Other important information is certain to result as research continues with the TIROS pictures obtained during this unique period.

ACKNOWLEDGMENT

The author has worked closely with Dr. Harry M. Johnson on many of the problems related to the determination of flow and identification of cloud features from the satellite photographs. His assistance in this respect is gratefully acknowledged. In addition, the active cooperation and support of staff members of the Meteorological Satellite Laboratory, NWSC, in consultation, and the use of their facilities is sincerely appreciated.

REFERENCES

1. H. F. Hawkins, Jr., L. G. Pardue, Jr., and C. Reber, "The National Hurricane Center," *Weatherwise*, vol. 14, No. 3, June 1961, pp. 87–98 (p. 92).
2. H. V. Senn, H. W. Hiser, and E. F. Low, "Studies of the Evolution and Motion of Hurricane Spiral Bands and the Radar Echoes which Form Them," *Final Report*, to U.S. Weather Bureau on Contract No. Cwb 9480, Marine Laboratory, University of Miami, Coral Gables, Fla., Aug. 1959.
3. R. E. Nagle and R. H. Blackmer, Jr., "The Use of Synoptic-Scale Weather Radar Observations in the Interpretation of Satellite Cloud Observations," Stanford Research Institute, Contract AF19(628)–284, Dec. 1962.
4. G. E. Dunn and B. I. Miller, *Atlantic Hurricanes*, Louisiana State University Press, Baton Rouge, La., 1960, 326 pp. (pp. 89–90).
5. R. W. Fett, "Aspects of Hurricane Structure: New Model Considerations Suggested by TIROS and Project Mercury Observations," to be published.